



Berkeley Arsenic Alleviation Group 2008 Summer Fieldwork Trip Report

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Background

The goal of the Berkeley Arsenic Alleviation Group (BAAG) is to design a water treatment system that uses ARUBA (Arsenic Removal Using Bottom Ash) to remove arsenic from drinking water in rural Bangladesh. In addition, our multidisciplinary team of students, researchers, and professors from engineering, science, social science, business, and public health aims to develop a sustainable and scalable implementation plan for the development of community-scale treatment centers in villages in Bangladesh.

As part of this project BAAG students traveled to Bangladesh twice in 2007 to conduct technical fieldwork. Results of the field visits were very promising and so team members traveled back to Bangladesh during the summer of 2008 to:

1. Design and test a community-scale prototype
2. Conduct experiments to determine parameters that affect the capacity of ARUBA to remove arsenic in real Bangladesh groundwater
3. Deploy a public health & socioeconomic study
4. Research the market for clean drinking water in rural communities
5. Develop contacts and collaborations

Logistics

Five Berkeley students traveled to Bangladesh during the summer of 2008 to conduct fieldwork for BAAG. In addition, principle investigator and faculty advisor Professor Ashok Gadgil joined the group for several days in Dhaka (June 25-28). Three of the students—Johanna Mathieu, Kristin Kowolik, and Shefah Qazi—worked on the technical aspects of the ARUBA project. Johanna and Shefah began work on May 31, 2008. Kristin joined them on June 16, 2008. Technical work was concluded on July 3, 2008. William Babbitt spent nearly three months in Bangladesh (May 31 to August 18, 2008) developing and deploying the public health and socioeconomic study. Tasnuva Khan was in Bangladesh from June 28 to July 21, working with William and also conducting research related to development of an ARUBA licensing plan.



Photo: The technical team at BUET, Dhaka (left to right): Mahbuba Jasmin Ahmed (BUET), Shefah Qazi, Dr. A.B.M. Badruzzaman (BUET), Dr. Ashok Gadgil, Johanna Mathieu, and Kristin Kowolik (June 2008)

Technical Results

The bulk of our technical research was conducted at the Bangladesh University of Engineering and Technology (BUET) in Dhaka, where we have developed a collaboration with Dr. A.B.M. Badruzzaman of the Civil Engineering Department. Dr. Badruzzaman provided us with lab space and resources for our work, including access to arsenic testing facilities at the university. In addition, we have begun working with one of his students Mahbuba Iasmin Ahmed, an MSc student in the Department of Civil Engineering at BUET. This summer Mahbuba learned how to make ARUBA, treat contaminated water, and take water samples for analysis. Four batches of ARUBA were made in Bangladesh and they were found to have the same arsenic removal capacity as ARUBA made in Berkeley.



Photo: Kristin Kowolik (left) and Mahbuba Iasmin Ahmed (right) measure water parameters (pH, DO, and arsenic concentration) at a tubewell in Besgao. Photo credit: Shefah Qazi (June 2008)

We conducted four field visits in two geographically distinct areas of the country (Besgao Village, Sreenagar Upazila, Munshiganj District and North Noluta, Matlab Upazila, Chandpur District) over the course of the summer in order to perform onsite experiments and to collect water for further experiments in the laboratory. In both of these villages—which we had never visited before—we were able to confirm ARUBA’s ability to remove high levels of arsenic from groundwater (800ppb to 20ppb, well below the WHO limit of 50ppb for Bangladesh), supporting results obtained in March and July 2007. Experiments also showed that ARUBA media could be used with a direct mass to volume scale up. We demonstrated that using 1.0 grams of ARUBA for 250 milliliters works as well as using 80 grams in 20 liters. Though results from the summer of 2007 were inconclusive, we are now confident in saying that ARUBA treatment is scalable.



Photo: Shefah Qazi tests the small-scale prototype clarifier in the BUET laboratory. Photo credit: Johanna Mathieu (June 2008)

Our main challenge in Bangladesh was to design and construct a scale model (10x scale down) of a community-scale system (4000 liters/day: enough drinking water for 2000 people/day) to remove arsenic from drinking water. In the Spring of 2008, we conducted several experiments at the Lawrence Berkeley National Lab and learned that ARUBA particle sizes are too small for effective sand filtration. Moreover, using a filter with finer particles would necessitate pumping the water through the filter in order to achieve reasonable flowrates, raising the cost of the overall system. Therefore, we chose not to pursue filtration and instead explored settling ARUBA particles with a laminar clarifier, as a way of removing the media from treated water.

We built and tested a 20 liter clarifier and found it effective in allowing ARUBA to settle out of water. The settling rate is increased through addition of a polyelectrolyte coagulant, which we purchased locally. We designed and commissioned a 400 liter clarifier. Mahbuba is currently working with this system, which has been temporarily installed at BUET for testing.

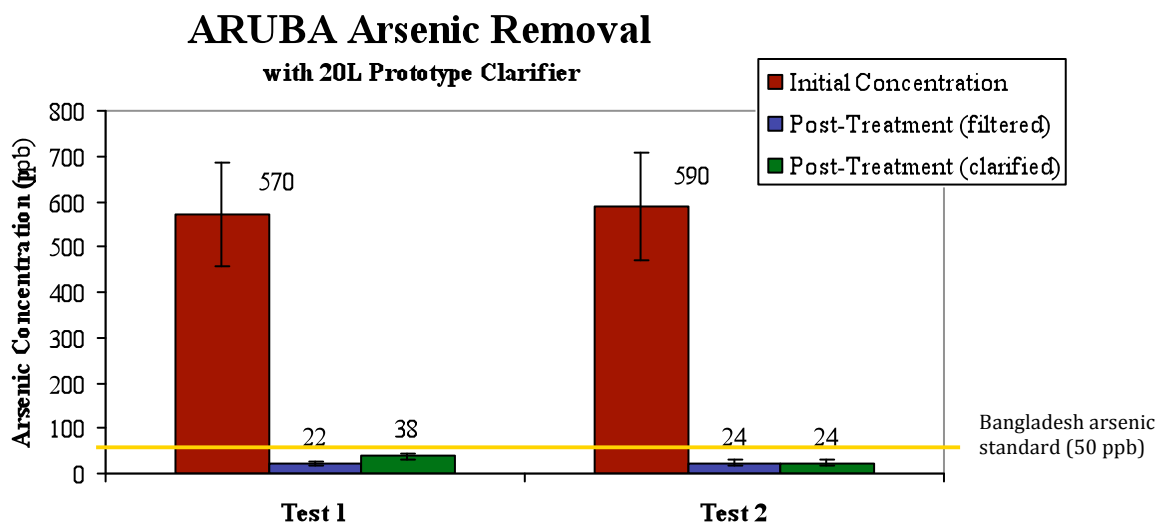


Figure: Using ARUBA to treat large volumes (20 liters) of Bangladeshi groundwater was found to work well, implying that ARUBA treatment is scalable. After mixing ARUBA into arsenic-contaminated water (~580 ppb) for one hour, we removed the ARUBA by (1) filtration and (2) clarification and tested for total final arsenic concentration to compare the results of the two processes. The clarifier works nearly as well as the filter.

In addition to our work in Bangladesh, a team of Berkeley students working on another low-cost arsenic removal technology (ElectroChemical Arsenic Remediation) tested ARUBA in Cambodia and found it to work approximately as well as in Bangladesh, indicating that the effectiveness of ARUBA is not specific to Bangladeshi groundwater. Therefore, it may be possible to use ARUBA to remove arsenic in other arsenic-affected areas of the world such as areas of Central and South America.

Public Health & Socioeconomic Results

A 22 page combined public health and socioeconomic survey was developed with the help of researchers at BRAC University in Dhaka, where we have a collaboration with Dr. Zainab Ali, Director of Student Affairs. The survey was approved by the University of California, Berkeley Committee for the Protection of the Human Subjects (CPHS).

To increase our understanding of local perceptions of the arsenic problem, several semi-structured interviews were conducted in different villages at the beginning of the summer. Using knowledge gained through these interviews and the expertise of our Bangladeshi colleagues, we were able to develop a culturally appropriate survey, which is sensitive to the issues in arsenic-affected communities.

The goals of the survey and interview portion of the project were to:

1. Understand the value attributed to arsenic-free water using econometric and contingent valuation methodology.
2. Determine factors that could explain why certain families placed a higher value on clean water than others.
3. Discover the relationship between the villagers and previous efforts at arsenic remediation.



Photo: William Babbitt measures the arsenic concentration of a tubewell in Matlab Upazila before interviewing the well owner about the value his family places on clean drinking water. Photo credit: Shefah Qazi (June 2008)



Photo: Survey enumerator, Khurshid (center), interviews a woman in Dharmanagar village (Comilla district) about her perceptions of the arsenic problem. Photo credit: William Babbitt (July 2008)



Photo: Survey enumerator, Rahim (right) poses with four children in Telishair village (Chandpur district). Photo credit: William Babbitt (July 2008)



Photo: Field assistant, Anisur Rahman (right), at an arsenic-contaminated tubewell (500 ppb), the primary drinking water source for a mosque in Besgao Village. Photo credit: Shefah Qazi (June 2008)

Over a 37 day span, 665 surveys were conducted (in the local language, Bengali) in 72 arsenic-affected villages and 15 arsenic-free villages. Currently we are in the process of entering and coding the data collected during the summer, so statistical analyses have not yet been performed. However, certain trends seem to emerge. The following findings are anticipated:

1. The average value placed on clean water in rural Bangladesh is well within the scope of the expected costs of a filtration plant.
2. Several factors including income, education, health status, access to clean water, and the presence of arsenic are expected to correlate with the value attributed to arsenic-free water.
3. Previous failed efforts to alleviate the arsenic problem have neglected to take into account the time and effort costs associated with arsenic removal.

The results from this survey will help us to develop a business and distribution model that would best serve the needs of this population.

Reflections

In Noluta village (Matlab Upazila, Chandpur District), we found that nearly every tubewell we tested except one was affected by arsenic. This village was located in one of the most arsenic-affected regions of Bangladesh, yet no organization had come to test the tubewells. In an interview with several village leaders, they expressed to us that they were frustrated with what seemed to them a total disregard for their village. One said to us, "We drink the bad water because we don't know any better. We greatly desire a proper education so that we will be motivated to change this." It is clear that an effective technology, such as ARUBA, will only be successful if it is accompanied by a sustainable implementation plan and education campaign.

BAAG members who had not yet traveled to the field were able to witness firsthand the problem that their hard work has aimed to address. Kristin Kowolik, who has been working on arsenic remediation projects at LBNL for more than two years, explains, "Traveling to villages and interacting with the locals, especially with the children, made a big impact. The experience underlined the urgency that the arsenic problem needs to be addressed and arsenic removal technologies need to be made available to the local population."

Speaking with the villagers directly in their native language (Bengali), both Tasnuva Khan and Shefah Qazi were able to learn of many subtleties that help us in our understanding of the problem. For instance, in a village not far from Dhaka, we found that most villagers had a tubewell in their yard that would provide them with water for all their needs. Some mentioned that if their tubewells were known to be contaminated with arsenic (marked red), they would merely walk to the next house and use their neighbor's well, thus negating the need for an arsenic-free water source. However, others in the same village indicated that their neighbors did indeed mind if they were to use someone else's well, and so they would be left with no alternative but to drink arsenic-contaminated water. Clearly the situation, even within individual villages, is extraordinarily complex.

Future Work

Over the next year, we will be working with Mahbuba Iasmin Ahmed who will test the 400 liter prototype arsenic removal plant in two geographically distinct villages of Bangladesh, for her MSc project. We hope to discover the optimal ARUBA and coagulant doses (and how they vary with different water compositions) and improve the design of the treatment system.

We are currently preparing technical results from our three field visits to Bangladesh for publication. In addition, we plan to present our findings at several conferences this academic year.

William Babbitt plans to travel back to Bangladesh for six weeks over winter break ('08-'09) to finish the public health and socioeconomic study, aiming to double the number of survey responses collected from rural villagers.

As a team, our main goal this year is to license ARUBA technology to a company that will develop community-scale water treatment facilities in rural Bangladesh. We are using the data, information, and contacts we developed in Bangladesh to draft a licensing plan that we will refine with a business team, which we are in the process of recruiting.



Photo: Four hundred liter prototype water treatment system consisting of a mixing tank, clarifier, and storage tank, which is temporarily installed at BUET for testing. Photo credit: Mahbuba Iasmin Ahmed (July 2008)